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(54) APPARATUS AND METHOD FOR GENERATING PILOT BEACON SIGNAL IN BASE STATIONS OF CDMA SYSTEM

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(57) ABSTRACT

An apparatus for generating pilot beacon signals for handoff between base stations having a different frequency assignment FA in a code division multiple access CDMA radio communication system includes a PN code generating unit for generating inphase (I)-channel and quadrature (Q)-channel pseudo noise (PN) sequences; a pulse shaping unit for shaping an I-channel PN signal and a Q-channel PN signal by filtering the I-channel and Q-channel PN sequences; an equalizing unit for equalizing phases of the I-channel PN signal and the Q-channel PN signal and generating an equalized I-channel signal and an equalized Q-channel signal; an interpolation filtering unit for converting frequencies of the equalized I-channel signal with the equalized Q-channel signal to intermediate frequencies (IF) and generating an IF I-channel signal and an IF Q-channel signal; a modulation unit for modulating IF I-channel and Q-channel signals and generating a modulated I-channel signal and a modulated Q-channel signal; combining unit for combining the modulated I-channel signal with the modulated Q-channel signal and generating a digital pilot beacon signal; and a D/A conversion unit for converting the digital pilot beacon signal into an analog pilot beacon signal.

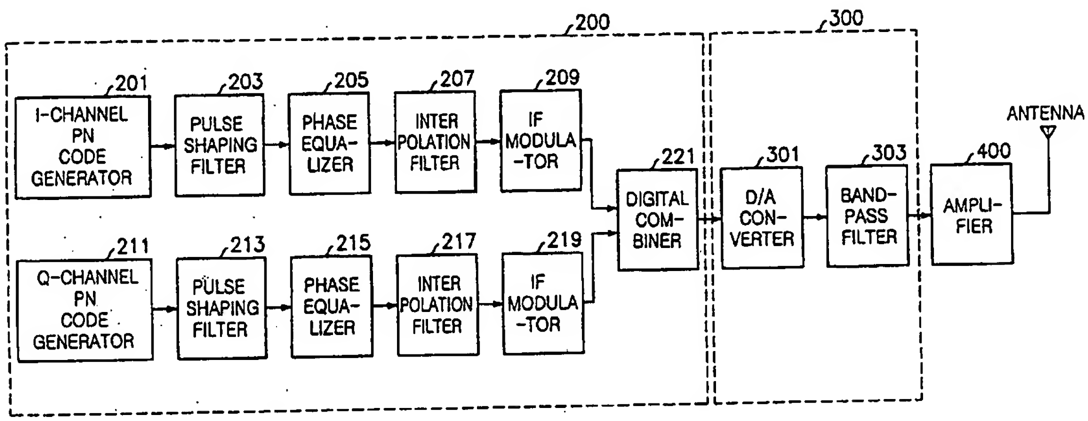


FIG. 1
(PRIOR ART)

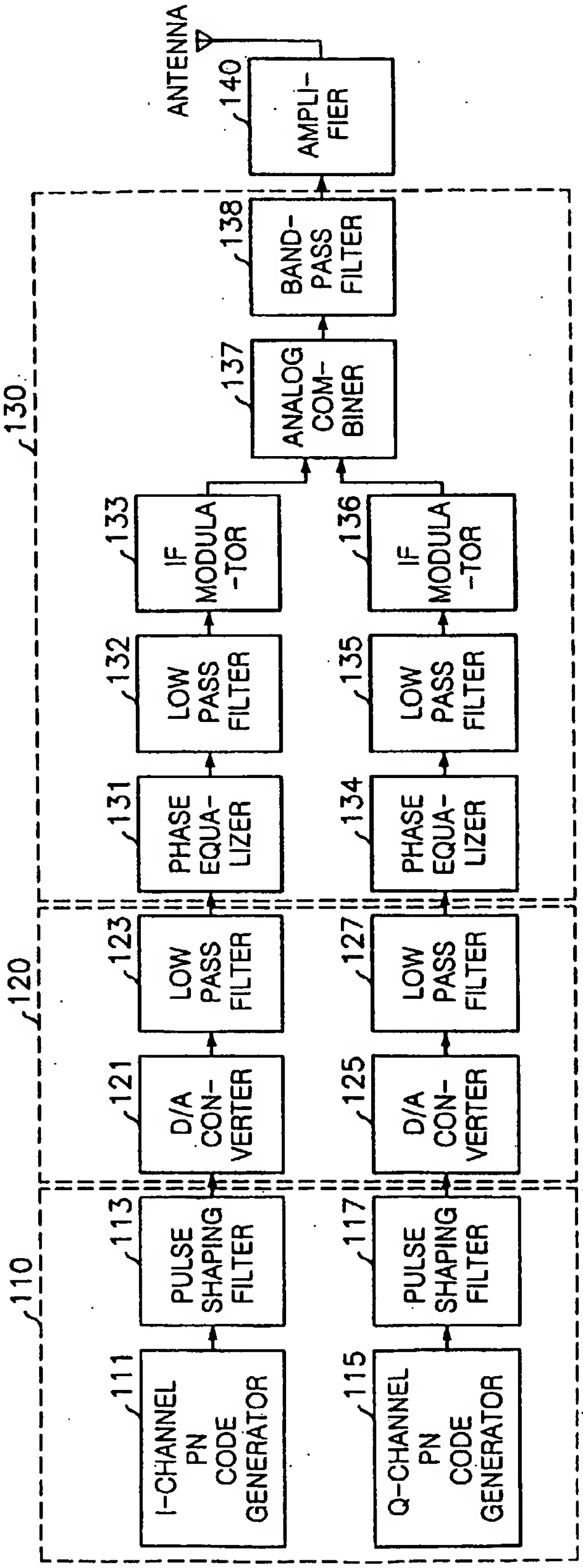
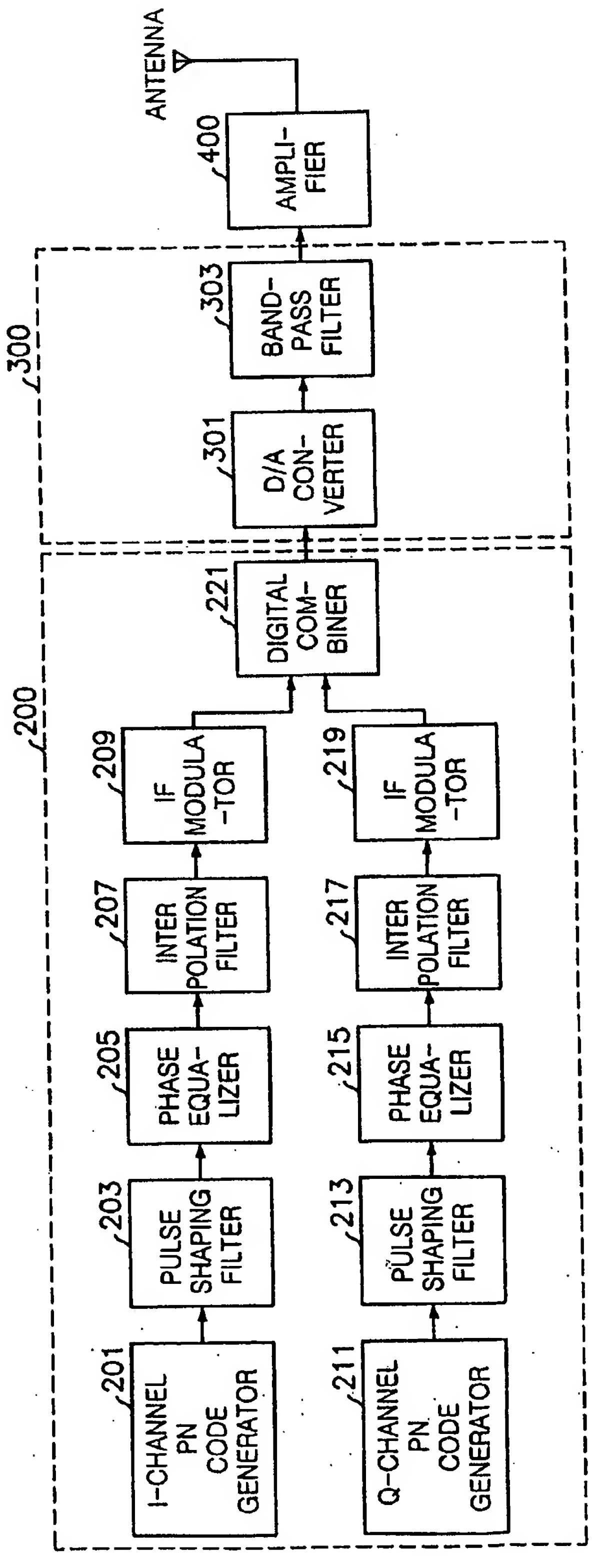


FIG. 2


ANTENNA
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213
PULSE
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201
I-CHANNEL
PN
CODE
GENERATOR
211
Q-CHANNEL
PN
CODE
GENERATOR

# APPARATUS AND METHOD FOR GENERATING PILOT BEACON SIGNAL IN BASE STATIONS OF CDMA SYSTEM

## CROSS-REFERENCE TO RELATED APPLICATIONS AND CLAIM OF PRIORITY

[0001] The present application is a continuation-in-part of U.S. application Ser. No. 09/362,068, filed in the U.S. Patent and Trademark Office on Jul. 28, 1999, priority thereof being hereby claimed under 35 USC 120.

## FIELD OF THE INVENTION

[0002] The present invention relates to an apparatus and method for generating a pilot beacon signal, particularly to an apparatus and method for generating a pilot beacon signal for handoff between base stations having a different frequency assignment (FA) in a code division multiple access (CDMA) radio communication system.

## DESCRIPTION OF RELATED ART

[0003] **FIG. 1** is a block diagram illustrating a conventional pilot signal generator for a base station in a CDMA communication system.

[0004] The pilot signal generator includes a digital channel signal processing unit **110**, an analog signal processing unit **120**, a sector connection processing unit **130**, an up-converter **140** and an amplifier **150**.

[0005] The digital channel signal processing unit **110** includes an in-phase (I)-channel pseudo noise (PN) code generator **111**, a quadrature (Q)-channel PN code generator **115** and pulse shaping filters **113** and **117**.

[0006] The I-channel PN code generator **111** generates and outputs the I-channel PN code sequences. The pulse shaping filter **113** shapes an I-channel PN signal by filtering the PN code sequence received from the I-channel PN code generator **111**. The Q-channel PN code generator **115** generates and outputs Q-channel PN code sequences. The pulse shaping filter **117** shapes a Q-channel PN signal by filtering the Q-channel PN code sequence received from the Q-channel PN code-generator **115**.

[0007] The analog signal processing unit **120** includes digital to analog (D/A) converters **121** and **125** and low pass filters **123** and **127**.

[0008] The D/A converter **121** converts the I-channel PN code signal shaped in the pulse shaping filter **113** to an analog signal. An undesired component of the PN signal is generated during conversion to the analog signal. The low pass filter **123** removes this undesired component and extracts a desired band of the I-channel PN signal from the D/A converter **121**. The Q-channel PN signal shaped in the pulse shaping filter **117** is converted into an analog signal and an undesired band of the Q-channel signal is filtered out in the D/A converter **125** and the low pass filter **127**.

[0009] The sector connection processing unit **130** includes phase equalizers **131** and **134**, low pass filters **132** and **135** and IF modulators **133** and **136**, an analog combiner **137** and a band pass filter **138**.

[0010] The phase equalizer **131** compensates a phase of the I-channel signal from the D/A converter **123**. The low pass filter **132** removes an undesired component generated during equalization, extracts and provides the IF modulator **133** with a desired band of the equalized I-channel PN signal.

[0011] The IF modulator **133** modulates an intermediate frequency signal that has been converted from the low frequency signal to an intermediate frequency signal by an up-converter (not shown).

[0012] On the other hand, a Q-channel PN signal is converted to a Q-channel analog IF modulated signal in similar way with the I-channel PN signal through the Q-channel PN code generator **115**, the pulse shaping filter **117**, the D/A converter **125**, the low pass filter **127**, the phase equalizer **134**, the low pass filter **135** and the IF modulator **136**.

[0013] The analog combiner **137** combines the I-channel PN signal with the Q-channel PN signal from the IF modulators **133** and **136**. The band pass filter **138** filters out an undesired band of the combined signal, converts the intermediate frequency of the filtered signal to a high frequency signal and generates a pilot signal. The amplifier **140** amplifies the pilot signal to be radiated through the antenna.

[0014] The conventional pilot signal generator as mentioned above uses more analog components than digital components. These analog components are complicated and large. Also, the analog components are sensitive to noise. Accordingly, when mounting analog components on a board, the integration density of these analog components is lower. The noise of the analog components prevents the communication system from being stabilized.

[0015] Further, in a conventional digital communication system, since the pilot signal is generated and transmitted along with the traffic signal through a modem for the CDMA base station, there is a problem in that the pilot signal affects other mobile stations as an interference signal.

## SUMMARY OF THE INVENTION

[0016] Therefore, it is an object of the present invention to provide an apparatus and method for generating pilot beacon signals, which reduces noise of the pilot beacon signal and stabilizes the communication system.

[0017] It is further another object of the present invention to provide an apparatus for generating pilot signals, having a higher integration density.

[0018] It is still further another object of the present invention to provide an apparatus for generating pilot signals, which generates and transmits only a pilot signal so as to reduce interference with other mobile stations.

[0019] In accordance with an aspect of the present invention, an apparatus is provided for generating pilot beacon signals for handoff between base stations having a different frequency assignment (FA) in a code division multiple access (CDMA) radio communication system, the apparatus including: a PN code generating unit for generating inphase (I)-channel and quadrature (Q)-channel pseudo noise (PN) sequences; a pulse shaping unit for shaping an I-channel PN signal and a Q-channel PN signal by filtering the I-channel and Q-channel PN sequences; an equalizing unit for equalizing phases of the I-channel PN signal and the Q-channel PN signal and generating an equalized I-channel signal and

an equalized Q-channel signal; an interpolation filtering unit for converting frequencies of the equalized I-channel signal with the equalized Q-channel signal to intermediate frequencies (IF) and generating an IF I-channel signal and an IF Q-channel signal; a modulation unit for modulating IF I-channel and Q-channel signals and generating a modulated I-channel signal and a modulated Q-channel signal; a combining unit for combining the modulated I-channel signal with the modulated Q-channel signal and generating a digital pilot beacon signal; and a D/A conversion unit for converting the digital pilot beacon signal into an analog pilot beacon signal.

[0020] In accordance with another aspect of the present invention, a method is provided for generating pilot beacon signals for handoff between base stations having a different frequency assignment (FA) in a code division multiple access (CDMA) radio communication system, the method including the steps of: a) generating inphase (I)-channel and quadrature (Q)-channel pseudo noise (PN) sequences with a PN code generating unit; b) shaping an I-channel PN signal and a Q-channel PN signal by filtering the I-channel and Q-channel PN sequences with a pulse shaping unit; c) equalizing phases of the I-channel PN signal and the Q-channel PN signal and generating an equalized I-channel signal and an equalized Q-channel signal with an equalizing unit; d) converting frequencies of the equalized I-channel signal with the equalized Q-channel signal to intermediate frequencies (IF) and generating an IF I-channel signal and an IF Q-channel signal with an interpolation filtering unit; e) modulating IF I-channel and Q-channel signals and generating a modulated I-channel signal and a modulated Q-channel signal with a modulation unit; f) combining the modulated I-channel signal with the modulated Q-channel signal and generating a digital pilot beacon signal with a combining unit; and g) converting the digital pilot beacon signal into an analog pilot beacon signal with a D/A conversion unit.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The above and other objects and features of the present invention will become apparent from the following description of the preferred embodiments given in conjunction with the accompanying drawings, in which:

[0022] **FIG. 1** is a block diagram illustrating a conventional pilot signal generator for a base station; and

[0023] **FIG. 2** is a block diagram illustrating a pilot beacon signal generator for a base station in accordance with the present invention.

## DETAILED DESCRIPTION OF THE INVENTION

[0024] Hereinafter, an embodiment according to the present invention will be described in detail referring to **FIG. 2**.

[0025] **FIG. 2** shows a block diagram illustrating a pilot beacon signal generator for a base station in accordance with an embodiment of the present invention.

[0026] The pilot beacon signal generator includes a digital pilot beacon signal generating unit **200**, an analog signal processing unit **300** and an amplifier **400**. The digital pilot beacon signal generating unit **200** includes an in-phase (I) PN code generator **201**, a quadrature (Q) PN code generator **211**, pulse shaping filters **203** and **213**, phase equalizers **205** and **215**, interpolation filters **207** and **217**, IF modulators **209** and **219** and a digital combiner **221**.

[0027] Referring to **FIG. 2**, in the present invention, digital phase equalizers **205** and **215**, digital IF modulators **209** and **219**, and a digital combiner **221** are used instead of analog components having the same functions. Also, interpolation filters are added for adjusting sampling frequencies.

[0028] The pilot beacon signal is used for a hard handoff between base stations having a different frequency assignment (FA) in the CDMA radio communication system. The beacon signal generator should be designed based on parameters related to time delay and phase distortion occurred in signal transmission between the CDMA base station and the mobile station. Accordingly, in the present invention, interpolation of filter coefficient is important for performing the same operation as the conventional pilot beacon signal generator and generating a stable pilot beacon signal.

[0029] For digital intermediate frequency (IF) modulation, it is necessary to use at least four times the number of samples used for the pulse shaping filter and the phase equalizer. Accordingly, a pilot beacon signal generator of the present invention increases the number of samples by using the interpolation filter, increasing the number of samples after the phase equalizer.

[0030] The I-channel PN code generator **201** generates and outputs an I-channel PN code sequence. The pulse shaping filter **203** shapes an I-channel PN signal by filtering the PN code sequence from the I-channel PN code generator **201**. In this embodiment, the pulse shaping filter **203** is implemented by a finite impulse response (FIR) filter, and coefficients of the FIR filter are modified regarding the interpolation filter **207**. In detail, the pulse shaping filter **203** performs over-sampling at four times the chip rate and contains 48 tab coefficients each of which has 8 bit resolution. The tab coefficients of the pulse shaping filer **203** have values as follows:

[0031] Coeff[0]=−0.0078125

[0032] Coeff[1]=−0.0078125

[0033] Coeff[2]=0

[0034] Coeff[3]=0.0078125

[0035] Coeff[4]=0.03125

[0036] Coeff[5]=0.046875

[0037] Coeff[6]=0.046875

[0038] Coeff[7]=0.0390625

[0039] Coeff[8]=0.0078125

[0040] Coeff[9]=−0.015625

[0041] Coeff[10]=−0.0390625

[0042] Coeff[11]=−0.03125

[0043] Coeff[12]=0

[0044] Coeff[13]=0.0390625

[0045] Coeff[14]=0.0546875

[0046] Coeff[15]=0.0390625

[0047] Coeff[16]=-0.0078125

[0048] Coeff[17]=-0.0703125

[0049] Coeff[18]=-0.1015625

[0050] Coeff[19]=-0.0625

[0051] Coeff[20]=0.046875

[0052] Coeff[21]=0.203125

[0053] Coeff[22]=0.3671875

[0054] Coeff[23]=0.4609375

[0055] Coeff[24]=0.4609375

[0056] Coeff[25]=0.3671875

[0057] Coeff[26]=0.2265625

[0058] Coeff[27]=0.046875

[0059] Coeff[28]=-0.0625

[0060] Coeff[29]=-0.1015625

[0061] Coeff[30]=-0.0703125

[0062] Coeff[31]=-0.0078125

[0063] Coeff[32]=0.0390625

[0064] Coeff[33]=0.0546875

[0065] Coeff[34]=0.0390625

[0066] Coeff[35]=0

[0067] Coeff[36]=-0.03125

[0068] Coeff[37]=-0.0390625

[0069] Coeff[38]=-0.015625

[0070] Coeff[39]=0.0078125

[0071] Coeff[40]=0.0390625

[0072] Coeff[41]=0.046875

[0073] Coeff[42]=0.046875

[0074] Coeff[43]=0.03125

[0075] Coeff[44]=0.0078125

[0076] Coeff[45]=0

[0077] Coeff[46]=-0.0078125

[0078] Coeff[47]=-0.0078125

[0079] The phase equalizer **205** compensates phase of the I-channel PN signal from the pulse shaping filter **203**. The digital phase equalizer compensates for phase distortion of the receiving filter in the mobile station. The phase distortion characteristics of the mobile station are obtained by a transfer function expressed by an equation 1.

$$H_{mo}(s) = \frac{s^2 + \delta_{mo}\omega_{mo}s + \omega_{mo}^2}{s^2 - \delta_{mo}\omega_{mo}s + \omega_{mo}^2} \qquad \text{Eq. (1)}$$

[0080] where, a value of a damping factor is 1.36 ($\delta_{mo}$=1.36) a resonance frequency is expressed as: $\omega_{mo}=2\times\pi\times315000$. The transfer function of the phase equalizer is expressed as a following equation 2.

$$H_{pe}(s) = \frac{s^2 - \delta_{pe}\omega_{pe}s + \omega_{pe}^2}{s^2 + \delta_{pe}\omega_{pe}s + \omega_{pe}^2} \qquad \text{Eq. (2)}$$

[0081] where, a value of a damping factor is 1.36 ($\delta_{pe}$=1.36), a resonance frequency is expressed as: $\omega_{pe}=2\times\pi\times315000$.

[0082] In this embodiment, the phase equalizer **205** is implemented by a secondary IIR filter. A bilinear transfer equation of the IIR filter is expressed by an equation (3).

$$s = \frac{2}{T_s}\frac{1-z^{-1}}{1+z^{-1}} \qquad \text{Eq. (3)}$$

[0083] In the present invention, since the phase equalizer processes the signal by four times of chip rate, which is equal to output sampling frequency of the FIR filter,

$$T_s = \frac{1}{1228800\times 4}.$$

[0084] The transfer function of IIR Filter is expressed by an equation (4).

$$H(z) = \frac{C_3 + C_2z^{-1} + z^{-2}}{1 + C_2z^{-1} + C_3z^{-2}} \qquad \text{Eq. (4)}$$

[0085] where $C_2$=-1.45287892264133 and $C_3$=0.57918535386309

[0086] In this embodiment, I and Q phase equalizers are implemented as one unit instead of separate hardware units. In the phase equalizer performs at 8 times the chip rate instead of four times the chip rate, and multiplexes the I signal and the Q signal.

[0087] The interpolation filter **207** performs up-sampling of the equalized signal to an intermediate frequency signal having sampling frequency for a primary IF modulation and removes harmonic component. In more detail, the interpolation filter **207** up-samples the shaped PN signal at a sampling frequency that is four times the chip rate to an intermediate frequency signal at a sampling frequency that is 16 times the chip rate. In this embodiment, the interpolation filter is implemented by a FIR filter having 12 tab coefficients of 8 bit resolution. The values the tab coefficient of the FIR filter are shown as:

[0088] Coeff[0]=0.00781250

[0089] Coeff[1]=0.04296875

[0090] Coeff[2]=0.10546875

[0091] Coeff[3]=0.19531250

[0092] Coeff[4]=0.28906250

[0093] Coeff[5]=0.34765625

[0094] Coeff[6]=0.34765625

[0095] Coeff[7]=0.28906250

[0096] Coeff[8]=0.19531250

[0097] Coeff[9]=0.10546875

[0098] Coeff[10]=0.04296875

[0099] Coeff[11]=0.00781250

[0100] The up-converter **400** converts the low frequency signal from the phase equalizer **205** to a high frequency signal.

[0101] The Q-channel PN code generator **211** generates and outputs a Q-channel PN code sequence. The pulse shaping filter **216** shapes the PN code sequence from the PN code generator **211**. The phase equalizer **215** compensates the phase of the Q-channel PN code sequence from the pulse shaping filter **213**. The interpolation filter **217** converts the low frequency signal from the phase equalizer **215** to an intermediate frequency (IF) Q-channel signal. The IF modulator **219** modulates the IF Q-channel signal and generates a modulated Q-channel signal.

[0102] The digital combiner **221** combines the modulated I-channel signal with the modulated Q-channel signal from the interpolation filters **207** and **217**.

[0103] The analog signal processing unit **300** includes a D/A converter **301** and a band pass filter **303**. The D/A converter **301** converts the combined signal to an analog signal. The band pass filter **303** filters out an undesired band from the analog signal and extracts a desired band of a beacon signal. The amplifier **400** amplifies the analog signal from the band pass filter **303**. An amplified signal is radiated through the antenna.

[0104] The pilot beacon signal generator according to the present invention utilizes less analog components, which are complicated and sensitive to noise, and more digital component than the conventional beacon signal generator, thereby improving the integration density of the hardware and stabilizing the system. In other words, by using the digital phase equalizers, the digital up-converters and the digital combiner, multiple low pass filters are not necessary to be used in the present invention and the pilot beacon signal generator of the present invention is considerably smaller than that of the conventional pilot beacon signal generator. Furthermore, in the present invention, the digital signal processing unit **110**, the analog signal processing unit **120** and the sector connection processing unit **130** can be integrated into one chip, i.e., a digital pilot beacon signal generating unit.

[0105] Further, the pilot beacon signal generator of the present invention generates and transmits only a pilot signal used for a beacon signal, to thereby reduce interference with other mobile stations. Accordingly, the pilot beacon signal generator stabilizes the communication system and increases the quality of the signal.

[0106] As mentioned above, using the pilot beacon signal generator of the present invention, the communication system can be more stable, compact and cost-effective, because the pilot beacon signal generator is less affected by noise and has a high integration density.

[0107] Although the preferred embodiments of the invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

What is claimed is:

1. An apparatus for generating pilot beacon signals for handoff between base stations having a different frequency assignment (FA) in a code division multiple access (CDMA) radio communication system, the apparatus comprising:

a PN code generating means for generating inphase (I)-channel and quadrature (Q)-channel pseudo noise (PN) sequences;

a pulse shaping means for shaping an I-channel PN signal and a Q-channel PN signal by filtering the I-channel and Q-channel PN sequences;

an equalizing means for equalizing phases of the I-channel PN signal and the Q-channel PN signal and for generating an equalized I-channel signal and an equalized Q-channel signal;

an interpolation filtering means for converting frequencies of the equalized I-channel signal with the equalized Q-channel signal to intermediate frequencies (IF) and for generating an IF I-channel signal and an IF Q-channel signal;

a modulation means for modulating the IF I-channel and Q-channel signals and for generating a modulated I-channel signal and a modulated Q-channel signal;

a combining means for combining the modulated I-channel signal with the modulated Q-channel signal and for generating a digital pilot beacon signal; and

a D/A conversion means for converting the digital pilot beacon signal into an analog pilot beacon signal.

2. The method as recited in claim 1, further comprising:

a means for filtering the analog pilot beacon signal and extracting desired band of the analog pilot beacon signal and for generating a filtered pilot beacon signal; and

a means for amplifying the filtered pilot beacon signal.

3. The apparatus as claimed in claim 1, wherein the pulse shaping means performs over-sampling at four times a chip rate.

4. The apparatus as claimed in claim 3, wherein the interpolation filtering means performs sampling at 16 times the chip rate.

5. A method for generating pilot beacon signals for handoff between base stations having a different frequency assignment (FA) in a code division multiple access (CDMA) radio communication system, the method comprising the steps of:

a) generating inphase (I)-channel and quadrature (Q)-channel pseudo noise (PN) sequences with a PN code generating means;

b) shaping an I-channel PN signal and a Q-channel PN signal by filtering the I-channel and Q-channel PN sequences with a pulse shaping means;

c) equalizing phases of the I-channel PN signal and the Q-channel PN signal and generating an equalized I-channel signal and an equalized Q-channel signal with an equalizing means;

d) converting frequencies of the equalized I-channel signal with the equalized Q-channel signal to intermediate frequencies (IF) and generating an IF I-channel signal and an IF Q-channel signal with an interpolation filtering means;

e) modulating IF I-channel and Q-channel signals and generating a modulated I-channel signal and a modulated Q-channel signal with a modulation means;

f) combining the modulated I-channel signal with the modulated Q-channel signal and generating a digital pilot beacon signal with a combining means; and

g) converting the digital pilot beacon signal into an analog pilot beacon signal with a D/A conversion means.

6. The method as recited in claim 5, further comprising the steps of:

h) filtering the analog pilot beacon signal and extracting a desired band of the analog pilot beacon signal, and generating a filtered pilot beacon signal; and

i) amplifying the filtered pilot beacon signal.

7. The method as recited in claim 5, wherein over-sampling is performed by the pulse shaping means at four times a chip rate.

8. The apparatus as claimed in claim 7, wherein sampling is performed by the interpolation filtering means at 16 times the chip rate.

* * * * *